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THESIS

MODELING SEA-BASED SUSTAINMENT OF MARINE EXPEDITIONARY UNIT (SPECIAL OPERATIONS CAPABLE) (MEU(SOC)) OPERATIONS ASHORE

Robert Martin Hagan

September 1998

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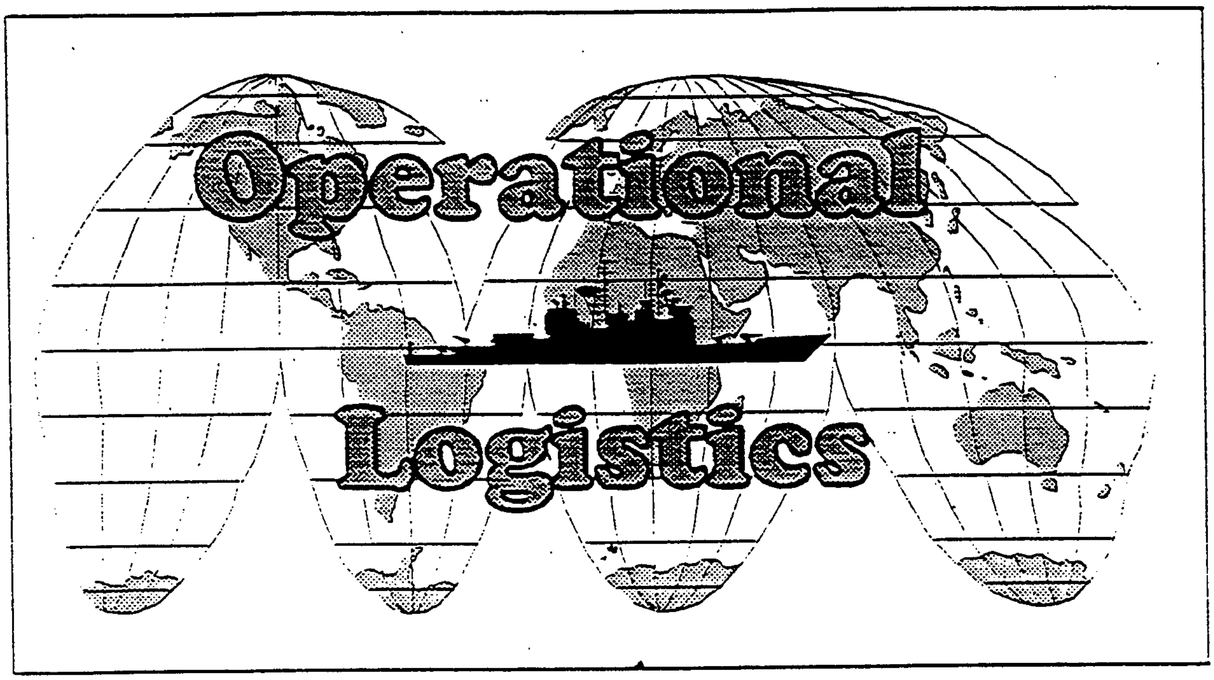
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The Marine Corps has embraced the concepts of Operational Maneuver From The Sea (OMFTS) and Ship-to-Objective Maneuver (STOM) as the next progression in the evolution of amphibious warfare. These related concepts envision harnessing emerging technologies to allow the projection of naval power ashore faster and from greater distances than in the past. Additionally, both concepts identify the ability to conduct sea-based logistics (SBL) as a key requirement for successful implementation. Sea-based logistics involves executing a wide range of logistical functions from a sea-base rather than from sites traditionally established ashore. Acknowleged enhancements are required to realize a complete SBL capability; however, the ability to provide some measure of sea-based sustainment exists today. This thesis models the sea-based sustainment of Marine Expeditionary Unit (Special Operations Capable) (MEU(SOC)) forces deployed from Amphibious Ready Group (ARG) ships. Missions are developed for analysis; each is coupled with an appropriate force force package of personnel and equipment density. Sustainment requirements and available transportation capacities are then determined and compared for each mission. This comparison along with several excursions provides insight into the nature of sea-based sustainment feasibility. It also gauges potential limitations for sea-based sustainment.

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ABSTRACT

The Marine Corps has embraced the concepts of Operational Maneuver From The Sea (OMFTS) and Ship-to-Objective Maneuver (STOM) as the next progression in the evolution of amphibious warfare. These related concepts envision harnessing emerging technologies to allow the projection of naval power ashore faster and from greater distances than in the past. Additionally, both concepts identify the ability to conduct sea-based logistics (SBL) as a key requirement for successful implementation. Sea-based logistics involves executing a wide range of logistical functions from a sea-base rather than from sites traditionally established ashore. Acknowledged enhancements are required to realize a complete SBL capability; however, the ability to provide some measure of sea-based sustainment exists today. This thesis models the sea-based sustainment of Marine Expeditionary Unit (Special Operations Capable) (MEU(SOC)) forces deployed from Amphibious Ready Group (ARG) ships. Missions are developed for analysis; each is coupled with an appropriate force package of personnel and equipment density. Sustainment requirements and available transportation capacities are then determined and compared for each mission. This comparison along with several excursions provides insight into the nature of sea-based sustainment feasibility. It also gauges potential limitations for sea-based sustainment.

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EXECUTIVE SUMMARY

The Marine Corps has embraced the concepts of Operational Maneuver From The Sea (OMFTS) and Ship-to-Objective Maneuver (STOM) as the next progression in the evolution of amphibious warfare. Recently published OMFTS and STOM concept papers from the Marine Corps Combat Development Command (MCCDC) articulate the enhancements to warfighting capabilities envisioned with OMFTS and STOM as well as the requirements for their effective implementation. These concepts envision harnessing emerging technologies to allow the projection of naval power ashore faster and from greater distances than in the past. Additionally, both concepts identify the ability to conduct sea-based logistics (SBL) as a key requirement for successful implementation. Sea-based logistics involves executing a wide range of logistical functions from a sea-base rather than from sites traditionally established ashore. Acknowledged enhancements are required to realize a complete SBL capability; however, the ability to provide some measure of sea-based sustainment exists today.

This thesis models the sea-based sustainment of Marine Expeditionary Unit (Special Operations Capable) (MEU(SOC)) forces deployed from Amphibious Ready Group (ARG) ships. Missions are developed for analysis; each is coupled with an appropriate force package of personnel and equipment density. Sustainment requirements are determined using Marine Corps logistics planning factors (LPFs) for each mission. The expected availability of transportation assets is also determined using published planning factors. This analysis then models the time required to establish the force ashore

as a measure of the level of effort that must be expended before sustainment begins. Also modeled is the number of number of MV-22 Osprey sorties required to transport each mission's sustainment requirements from the ship-to-objective. Comparing the number of sorties required for sustainment to the number of sorties available provides insight into the level of competition for transporter assets. This comparison is continued in several excursions that test the model's sensitivity to changes in both sustainment requirements and expected transporter availability. Rather than issue a strict feasibility assessment, this analysis employs a scale of feasibility based on the percentage of available sorties required for sustainment purposes. This scale provides insight into the nature of sea-based sustainment feasibility. It also demonstrates potential limitations for sea-based sustainment.

Marine Corps planners continue to refine OMFTS, STOM, and SBL. These concepts are, however, firmly in place as the templates for future operations. This analysis demonstrates the inherent difficulty of sea-based sustainment over the distances associated with OMFTS. While these distances may not preclude surface-delivered sustainment, air-delivery is more likely. Air-delivered sustainment implies a high degree of competition for finite available sorties. This competition occurs because sustainment requires a significant percentage of available sorties that have traditionally been reserved primarily for tactical mobility requirements. This analysis revealed several situations where sustainment alone required more than the total amount of available sorties. Water and fuel requirements drive the demand for sustainment sorties. This occurs in part because of the manner in which they must be transported. Therefore, improvements in

how water and fuel are transported can have a direct impact on reducing the number of sorties required to transport them. Additionally, this analysis addresses a potential mix of surface landing craft in an OMFTS environment. The combined results of these examinations suggest that planners should continue to address the exact nature of sea-based sustainment of forces ashore. They also provide starting points for further, more detailed, analysis that can assist in the ongoing concept development.

I. INTRODUCTION

The Marine Corps has embraced the concepts of Operational Maneuver From The Sea (OMFTS) and Ship-to-Objective Maneuver (STOM) as the next progression in the evolution of amphibious warfare. Recently published OMFTS and STOM concept papers from the Marine Corps Combat Development Command (MCCDC) articulate the enhancements to warfighting capabilities delivered by OMFTS and STOM as well as the requirements for their effective implementation. Among the central requirements for each is the capability to sustain forces ashore from a sea-base rather than from the traditional support areas ashore that are established subsequent to the landing of initial ground forces.

Marine Corps forces typically deploy and operate as Marine Air-Ground Task Forces (MAGTFs). This operational structure provides a perspective from which an analysis of sea-based sustainment requirements can be conducted. As its title implies, a MAGTF is task-organized to provide operational flexibility; there are, however, standard MAGTF organizations. The Marine Expeditionary Unit (Special Operations Capable), (MEU(SOC)), is the standard forward-deployed MAGTF. Deployed in the ships of an Amphibious Ready Group (ARG) and possessing a variety of inherent mission capabilities, the MEU(SOC) is a viable candidate for sea-based sustainment examination.

This thesis models the sea-based sustainment of MEU(SOC) forces conducting missions ashore. These missions span the spectrum of conflict from peacetime through crisis to wartime operations. The forces ashore are described as force packages

comprised of people and equipment. Specific sustainment requirements are calculated for each force package using logistics planning factors (LPFs) from the Marine Corps' MAGTF Data Library (MDL), [Ref. 1]. The data provided by the determination of requirements is subsequently used to accomplish several objectives. First, those commodities that generate the most demanding sustainment requirements for each force package are determined. These commodities or "drivers" help scope the remaining analysis. Secondly, the time required to establish the force package ashore, i.e., transport it from ship-to-objective is modeled. This determination yields insight into the level of effort that must be expended before sustainment begins. Thirdly, the model estimates the effort required to provide sustainment to the force ashore and gauges the potential limitations of sea-based sustainment for the selected missions. Finally, the mix of surface landing craft in an OMFTS environment is addressed.

II. BACKGROUND

The purpose of this chapter is to provide the reader with an overview of the organizational structure and operational concepts modeled in this thesis.

A. MARINE AIR-GROUND TASK FORCE (MAGTF)

As documented in Marine Corps Doctrinal Publication 3 (MCDP 3), *Expeditionary Operations*, [Ref. 2], "the MAGTF is the Marine Corps' principal organization for missions across the range of military operations." This thesis employs a single type of MAGTF, the MEU(SOC). However, a description of the common MAGTF structure along with some details about the largest standard MAGTF, the Marine Expeditionary Force (MEF), is useful.

As illustrated in Figure 1, all MAGTFs are comprised of four elements: a command element (CE), a ground combat element (GCE), an aviation combat element (ACE), and a combat service support element (CSSE). These elements are task-organized, trained, and equipped to provide an operational decision-maker with what is described as a "rheostat of options and capabilities to vary the composition, scope, and size of the forces phased ashore." [Ref. 2]

The CE is normally a standing headquarters. In addition to the resident staff functions for the MAGTF Commander, the CE is organized to provide reconnaissance, intelligence, and communications capabilities in general support of the entire MAGTF. At the MEF level, these functions are organized in the Surveillance, Reconnaissance, and Intelligence Group (SRIG).

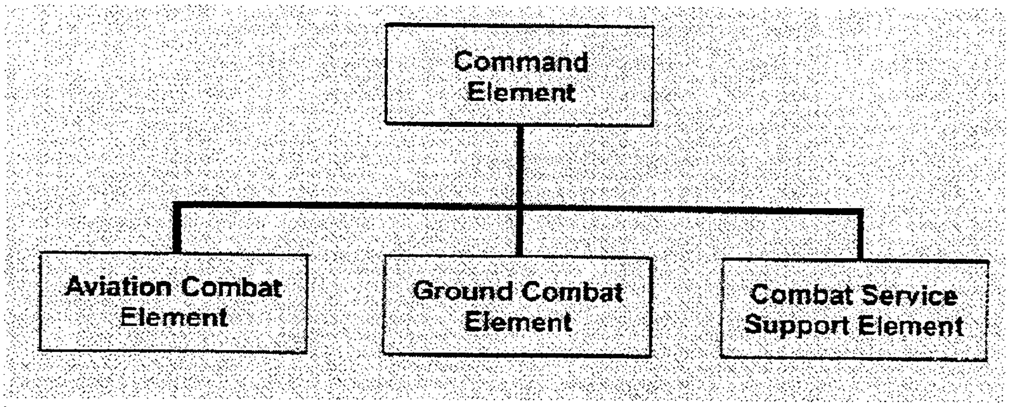

Figure 1. MAGTF Structure

A MAGTF's GCE is normally drawn from the MEF's GCE, the Marine Division. The GCE is built around units from one of the Division's infantry regiments reinforced with attachments from the artillery regiment, headquarters battalion, combat engineer battalion, light armored reconnaissance battalion, assault amphibian battalion and possibly the tank battalion as well. It is task organized to conduct ground operations. Logistically, the GCE possesses some organic transportation, supply, maintenance, and medical capabilities.

A MAGTF's ACE is drawn from the MEF's ACE, the Marine Aircraft Wing. The ACE is organized to provide "some or all of the six functions of Marine Aviation: antiair warfare, assault support, offensive air support, air reconnaissance, electronic warfare, and control of missiles and aircraft." [Ref. 2] The Marine Aircraft Wing is comprised of several types of subordinate units which are designated Groups. Marine Aircraft Groups contain fixed and/or rotary-wing aircraft squadrons along with a Marine Aviation Logistics Squadron for aviation supply, ordnance, and intermediate aircraft

maintenance. The Marine Air Control Group provides antiair missile units, as well as requisite command and control communications units. The Marine Wing Support Group provides aviation ground support units. Aviation ground support includes motor transportation, expeditionary airfield services, aircraft and structural fire fighting, meteorological services, general engineering, bulk fuel services, military police, and explosive ordnance disposal.

A MAGTF's CSSE is drawn from the MEF's CSSE, the Force Service Support Group. It is task-organized to provide "a full range of support functions" to the other MAGTF elements. [Ref. 2] This range of functions can span the six functions of combat service support (CSS): supply, maintenance, transportation, services, health services, and general engineering support.

B. MARINE EXPEDITIONARY UNIT (SPECIAL OPERATIONS CAPABLE) (MEU(SOC))

The MAGTF employed in this analysis, the MEU(SOC), represents the standard, forward-deployed Marine expeditionary organization. [Ref. 2]

The special operations capable (SOC) suffix is applied at the completion of an "intensive, predeployment training program" during which the MEU's elements must demonstrate proficiency in a series of missions that span the spectrum of operational intensity. There are seven standing MEU headquarters: the 11th, 13th, and 15th MEUs which deploy from California; the 22nd, 24th, and 26th MEUs which deploy from North Carolina; and the 31st MEU which deploys from Okinawa, Japan. Given available embarkation space on the ships of each MEU(SOC)'s associated ARG, a MEU

commander will deploy with the personnel and equipment density he deems appropriate for the MEU's area of operation. As a result, each MEU (SOC) deploys with similar but not exact duplicate amounts of people and equipment. This thesis employs data taken from recent 13th and 15th MEU(SOC) deployments, [Ref. 3] and [Ref. 4] respectively.

The MEU CE is a standing headquarters and staff. It is augmented for deployment by the SRIG with elements of Force Reconnaissance, the Intelligence Company that includes Counter-Intelligence, Interrogator-Translator, Signals Intelligence, and Topographic capabilities, and the Communications Battalion.

The MEU GCE is a Battalion Landing Team (BLT). A BLT is built around an infantry battalion with its staff, three Rifle Companies, a Weapons Company, and organic communications section augmented with an artillery battery, a combat engineer platoon, a Light Armored Reconnaissance Company (-), an Assault Amphibian platoon, and in some instances, a section of tanks. This analysis does not include tanks. Additionally, with the Advanced Amphibious Assault Vehicle (AAAV) identified as a key requirement for OMFTS, [Ref. 5], it is modeled in place of the current generation AAV.

The MEU ACE is designated as a Composite Squadron. It is normally built around a Marine Medium Helicopter Squadron (HMM) of 12 CH-46 Sea Knights. As the CH-46 is scheduled to be replaced by the MV-22 Osprey, this analysis uses the MV-22 for modeling purposes. The HMM is augmented by four CH-53E Sea Stallions from a Marine Heavy Helicopter Squadron as well as three UH-1N utility helicopters and four AH-1W Sea Cobra attack helicopters, both of which come from a Marine Light Attack Helicopter Squadron. A fixed-wing capability is provided by six AV-8B Harriers from a

Marine Attack Squadron. Additionally, the HMM is reinforced by elements of the Marine Air Control Group and the Marine Wing Support Group. These elements contribute antiair, communications, and forward refueling capabilities.

The MEU CSSE is designated as a MEU Service Support Group (MSSG). The MSSG consists of a staff, a supply detachment, a maintenance detachment, a motor transport detachment, a landing support detachment, a communications section, a health services detachment which includes a medical doctor and a dentist, an engineer support detachment, a military police section, as well as disbursing and postal representatives.

C. AMPHIBIOUS READY GROUP (ARG)

An ARG is the group of amphibious ships in which a MEU(SOC) deploys. Additionally, an ARG deploys with a detachment of landing craft from an Assault Craft Unit (ACU), an Explosive Ordnance Disposal Mobile Unit detachment, and a Navy Special Warfare detachment.

The number and mix of amphibious ships in an ARG varies with operational and maintenance availability. However, a typical ARG consists of a general-purpose amphibious assault ship (LHA/LHD), an amphibious transport dock (LPD), and a dock landing ship (LSD). The number and mix of landing craft is dependent on the amphibious ships represented. Currently, a typical landing craft mix is 4 Landing Craft Air-Cushion (LCAC) and 3 Landing Craft Utility (LCU). OMFTS envisions the LCAC as the sole surface landing craft. [Ref. 5]

In this analysis, the ARG consists of a LHD, a LPD, and a LSD with 7 LCAC; 3 with the LHD and 4 with the LSD. All aircraft are aboard the LHD. AAAVs are

embarked in the LPD. Additionally, it is important to keep in mind that the ARG serves as the sea-base from which forces are deployed and then sustained. It is assumed that the ARG and embarked MEU(SOC) deploy with the advertised 15 days of sustainment, [Ref. 2].

D. OPERATIONAL MANEUVER FROM THE SEA (OMFTS)

The Marine Corps' OMFTS Concept Paper, [Ref. 5], describes OMFTS as "a marriage between maneuver warfare and naval warfare." It is, in fact, the application of maneuver warfare concepts to traditional amphibious warfare doctrine. Maneuver warfare focuses on the dynamic character of conflict along with the skills and flexibility needed to adapt to rapidly changing environments. OMFTS seeks to minimize interruptions in tempo by focusing on operational objectives and using the sea as a maneuver space.

E. SHIP-TO-OBJECTIVE MANEUVER (STOM)

The Marine Corps' STOM Concept Paper, [Ref. 6], describes STOM as the concept for implementing OMFTS at the tactical level. It seeks to exploit advances in mobility, communications, and navigation systems. Whereas traditional amphibious doctrine required securing a beach lodgment from which combat power could be projected, STOM treats the beach as a waypoint to an inland objective: an area that can be used for landing throughput but avoided as an area in which to build up.

F. SEA-BASED LOGISTICS (SBL)

[Ref. 5] and [Ref. 6] both identify the ability to conduct SBL as a key requirement on the road to realizing new concepts. Traditionally, amphibious assaults have been

supported from areas established ashore. These areas required a significant amount of time and manpower to establish, secure and operate. The Marine Corps' SBL Concept Paper, [Ref. 7], describes the need to reduce shore based support facilities to an absolute minimum. Also detailed is the acknowledgement that full implementation of an effective SBL system will require improvements in several existing areas along with the introduction of new technologies. First, total asset visibility will be needed for both embarked and en route supplies. Currently, this is limited to the block of embarked supplies. Secondly, the capability to selectively offload within the seabase itself must be realized. While existing amphibious ships are not completely adequate in this regard, there is some opportunity for selective offload of equipment and supplies.

III. MODEL DEVELOPMENT

A. METHODOLOGY OVERVIEW

Modeling sea-based logistical sustainment required three distinct but dependent inputs: a specific mission, an associated force package, and the sustainment requirements for that force package. This section provides an overview of each input; following sections will offer greater detail.

In this type of modeling, analytical merit is predicated upon the mission around which the analysis is built. This renders valid mission development especially critical. The missions selected for analysis must be operationally reasonable. They must also provide enough detail to adequately capture sustainment measures. In this analysis, all missions used are consistent with current MEU(SOC) capabilities. For each mission, a general situation along with information on force composition and a brief concept of operations are provided. These serve not to capture every nuance associated with the mission; rather, they are provided to help the reader picture how a specific mission might be characterized.

With a mission selected, an associated force package was constructed. A force package is a description of the people and equipment required for the respective mission. The force packages are representative of the capabilities a MEU Commander might employ for a given mission. Specific responses can vary a great deal depending on issues ranging from rules of engagement to the level of host nation support opportunities.

Additionally, a MEU Commander's operational prerogative will greatly influence how missions are met.

Once a mission and its associated force package were developed, sustainment requirements were determined. Determining sustainment requirements involves matching the appropriate elements of each force package with their logistics planning factors (LPFs) from the MAGTF Data Library, [Ref. 1]. Also involved is conversion of sustainment requirements into movement requirements which are then assigned to specific transporters, both air and surface. The determination of movement requirements varies by sustainment commodity; this variation is coupled with differences in specific transporter roles.

Balancing the above inputs against the rules for determining the appropriate LPF and transportation mode yields an expected value model of sorties required to both establish the force ashore and then to sustain it. These figures are then matched by transporter type to yield expected sorties per day for each type. The time required to establish the force ashore is determined by the number of sorties required, the time per sortie for each transporter type, and the availability of each transporter. The model then provides insight into sustainment feasibility by comparing requirements with available sorties. This comparison is first conducted by using the expected values of all inputs. Further comparisons are based on excursions in both requirements and sorties available to determine the model's sensitivity to these inputs.

B. MISSION DEVELOPMENT

Missions were developed to provide a viable context for analysis. Five missions were selected from the current capabilities of a MEU(SOC) deployed in the amphibious ships of an ARG. In this analysis, a mission is characterized by its placement along the spectrum of conflict, an associated force package of people and equipment, a ship-to-shore distance, and a shore-to-objective distance. The missions reflect an OMFTS-type construct; contrasted with a traditional profile, the significant differences for modeling purposes are the movement distances involved, sea-based sustainment, and forces ashore that are primarily drawn from the GCE and CSSE with minimal CE and ACE assets ashore. Sea-based sustainment does not preclude the assignment of mobile Combat Service Support (CSS) assets such as motor transport to move people, cargo, fuel, and water ashore. Instead, the key difference under a sea-based concept is that all sustainment of the force ashore originates from the ARG rather than from established CSS Areas (CSSAs) ashore. An overview of mission characterization is provided in Table 1 at the end of this section.

1. Humanitarian Assistance/Disaster Relief (HA/DR)

a. *Situation*

A natural disaster occurs in a Third World nation resulting in a situation similar to that faced in Bangladesh following a 1991 typhoon. The deployment of an American Joint Task Force (JTF) is hampered by extensive damage to infrastructure such as airfields capable of receiving strategic airlift and ports capable of receiving strategic sealift. A deployed MEU (SOC) is detailed to provide an initial stabilizing response.

b. *Force Composition*

The force for this mission is built around the MEU(SOC)'s capabilities to generate and distribute logistical support. There is a limited need for command and control from the CE and security forces from the GCE. The GCE also contributes Light Armored Vehicles (LAVs) and Advanced Assault Amphibious Vehicles (AAAVs) for all terrain distribution capability and combat engineers for their construction skills. The ACE provides its bulk fuel capability and some communications assets. The CSSE provides the majority of the people and equipment ashore including motor transportation, general engineering, and health service capabilities.

c. *Concept of Ops*

Establish force ashore in order to distribute relief supplies, provide potable water, assist in clearing of debris, provide power generation in priority areas, and provide medical assistance. The focus of effort is primarily logistical. Storage for potable water, fuel, and limited dry supplies is needed ashore. This requires a blend of sea-based sustainment and traditional CSS provision. Sustainment requirements were determined only for the force ashore. In reality, the MEU (SOC) could very well provide limited supplies to people displaced by the disaster in the period before a Non-Governmental or Private Volunteer Organization like the Red Cross is able to provide support.

2. Semi-Permissive Non-Combatant Evacuation Operation (NEO(S-P))

a. *Situation*

A NEO is requested for a limited number of American citizens in a Third World nation capital. The operational environment is relatively stable but deteriorating, i.e., host government forces are receptive to the NEO but they are not in complete control of the affected territory or population. A deployed MEU(SOC) is ordered to conduct the mission.

b. *Force Composition*

The NEO mission, regardless of characterization, requires a liaison and coordination element drawn primarily from the CE. The semi-permissive nature of this mission requires a security force, in this case a Rifle Company with LAVs from the GCE. The ACE contributes both communications and anti-air capabilities while the CSSE provides the manning for the Evacuation Control Center (ECC). The ECC is responsible for processing evacuees based upon priorities established by the respective State Department staff.

c. *Concept of Ops*

Deploy the liaison and coordination element, security force, and ECC. Conduct the evacuation. Sustainment requirements will include subsistence, Class I; fuel, Class III; and ammunition, Class V (W) to the force ashore for the mission's duration.

3. Non-Permissive Non-Combatant Evacuation Operation (NEO(N-P))

a. *Situation*

Civil disorder in a Third World nation is rapidly deteriorating into chaos. Unlike the semi-permissive scenario, the host nation has no ability to control the situation. As a result, a larger, more capable force is required. A deployed MEU(SOC) is ordered to conduct the mission.

b. *Force Composition*

Compared with the semi-permissive NEO, the primary increase in manning for the non-permissive NEO is seen in a larger GCE force, which includes a command section ashore. Additionally, the ACE provides a forward refueling capability for what could evolve into a mission of longer duration. The CSSEs contribution also grows to deliver a more robust ECC.

c. *Concept of Ops*

Same as the NEO (S-P).

4. Security Operation

a. *Situation*

A deteriorating situation in a Third World nation threatens U.S. interests in the region. The situation is such that security is required at three geographically dispersed sites. Artillery support from a centrally located battery is required and feasible. CSS requirements can be delivered to a central location and distributed via motor transportation to each site.

b. *Force Composition*

The nature of a security operation requires a significant command presence from the GCE ashore. The CE will remain afloat. The GCE also contributes LAVs and AAAVs for mobility and anti-mechanized capabilities along with the infantry and artillery capabilities. The ACE provides air control communications, refueling and antiair assets. The CSSE provides a detachment consisting primarily of motor transportation and maintenance assets.

c. *Concept of Ops*

Establish a force ashore to include artillery in order to provide a secure perimeter around each site. Conduct the security operation until relieved of the requirement. Sustainment requirements include providing Class I, Class III, and Class V (W) to the force ashore.

5. Enabling Force Operation

a. *Situation*

An ongoing border dispute between two Third World nations intensifies with the invasion of one nation by the other. United States intervention is requested by the invaded nation. A deployed MEU (SOC) is directed to seize and secure both a port and an airfield to enable the deployment of follow-on forces.

b. *Force Composition*

The most intense mission analyzed, this mission requires the entire GCE ashore. The ACE provides air control communications, refueling and antiair assets. The CSSE provides motor transportation, general engineering, landing support, and maintenance assets.

c. *Concept of Ops*

Establish a force ashore to include artillery in order to seize and secure port and airfield. Sustainment requirements include providing Class I, Class III, and Class V (W) to the force ashore.

Table 1 summarizes key information for each mission.

Mission	People	Distances (miles) Ship-to-shore	Shore-to-objective	HMMWVs and Trailers	5-Ton Trucks	Logistics Vehicle Systems	Light Armored Vehicles	Advanced Assault Amphib Vehicles	M198 Howitzers
HA/DR	CE: 25 GCE: 158 ACE 24 CSSE: 210 417	5	30	67	21	5	14	13	0
NEO(S-P)	CE: 10 GCE: 269 ACE: 29 CSSE: 38 346	50	50	41	10	1	15	0	0
NEO(N-P)	CE: 20 GCE: 516 ACE: 35 CSSE: 80 651	50	50	51	15	1	15	0	0
Security Operation	CE: 0 GCE: 718 ACE 35 CSSE: 31 784	50	50	68	20	2	18	13	6
Enabling Force Operation	CE: 0 GCE: 1260 ACE 35 CSSE: 210 1505	50	50	118	30	5	18	13	6

Table 1. Mission Development Summary

C. REQUIREMENTS DETERMINATION

The daily sustainment requirements for each mission are functions of the number of personnel assigned to that mission, its equipment density, and the mission and phase for ordnance requirements. Sustainment requirements are determined by respective classes of supply. The classes of supply are:

- I. Subsistence (MREs and Water)
- II. Individual Equipment
- III. Petroleum, Oil, and Lubricants
- IV. Construction Materials
- V. Ammunition (W- Ground, A- Aviation)
- VI. Personal Demand Items
- VII. Major End Items
- VIII. Medical Supplies
- IX. Repair Parts
- X. Non-military Program Material

This analysis uses existing Marine Corps LPFs published in the MAGTF Data Library, [Ref. 1], to model Class I, Class III, and Class V (W) requirements for each mission. These classes of supply represent areas with viable LPFs; they also pose the greatest logistical challenge in nearly every situation. The remaining classes of supply either lack LPFs or they are not considered significant for the types of missions analyzed. This analysis, where appropriate, further categorizes requirements into dry (MREs and ammunition) and wet (water and fuel). For dry requirements, the weight which must be carried is calculated; for wet requirements, the number of gallons which must be transported is calculated. This categorization is necessary when determining subsequent transportation requirements. Once transported ashore, dry requirements are loaded into trucks for ground movement and distribution. Ashore, the loading of dry requirements may be assisted by a limited amount of material handling equipment, but the bulk of the

loading will be strong-back labor. Wet requirements, both water and fuel, are transported ashore in 500-gallon bladders. Once ashore, water is transferred to either 900-gallon containers known as SIXCONS transported on Logistics Vehicle Systems (LVS) or to water trailers towed by 5-ton trucks. Once ashore, fuel is transported by SIXCONS on LVSs or in 500-gallon bladders loaded in the bed of a 5-ton truck.

1. Class I

Class I (food and water) requirements are a function of the number of people involved in the mission. Daily MRE requirements are computed and converted to a pounds per day figure using the following equation:

$$M = \mathrm{N} * \mathrm{D} * \mathrm{P}$$

Where M = total daily MRE requirements in pounds
N = number of people ashore
D = daily MRE requirement per person, (3)
P = weight in pounds of one MRE including packaging, [Ref. 8].

At a certain point, hot meals and fresh fruits and vegetables will be provided for at least one meal per day. For modeling purposes, MRE figures are used exclusively.

Daily water requirements are computed using the following equation:

$$H = \mathrm{N} * \mathrm{W}$$

Where H = daily water requirement in gallons
N = number of people ashore
W = daily water planning factor in gallons, [Ref. 1].

The range for W provided in [Ref. 1] is 10 gal/day to 24 gal/day. In this analysis, 10 gal/day is used exclusively.

2. Class III

Class III (fuel) requirements are a function of equipment type. In this analysis, a single fuel type (F-44) is modeled. For each item of equipment, a daily requirement is computed based on planning factors for gallons per hour and operating hours per day. This relationship is reflected in the following equation:

$$F=\sum_{j} X_j * Y_j * E_j$$

Where F = total daily fuel requirement in gallons
X_j = fuel use in gallons per hour for equipment type j, [Ref. 1]
Y_j = operational hours per day for equipment type j, [Ref. 1]
E_j = number of equipment type j ashore.

3. Class V (W)

Class V (W) (ground ammunition) requirements are a function of ammunition type, weapon type, threat, the particular MAGTF element employing the weapon, and the phase of combat. In this analysis, a composite threat is assumed for computing all class V (W) requirements. This threat level is intended for uncertain environments where the opposition is primarily infantry and there is potential for reinforcement by mechanized forces.

Daily ammunition requirements can be computed from the following equation:

$$A=\sum_j Q_{ij}*Y_i*V_j \ \forall i$$

Where A = total daily ammunition requirement in pounds
Q_{ij} = rounds per day of type i used by weapon type j, [Ref. 1]
Y_i = weight of ammunition type i round in pounds, [Ref. 8]
V_j = number of weapon type j ashore.

4. Summary

Table 2 summarizes sustainment requirements for each mission.

Mission	MREs (lbs)	Water (gals)	Fuel (gals)	Assault Rate Ammunition (tons)	Sustained Rate Ammunition (tons)
HA/DR	1826	4170	4924	0	0
NEO(S-P)	1515	3460	3924	6	2
NEO(N-P)	2851	6510	4749	7	2
Security Op	3434	7840	7177	25	6
Enabling Force Op	6592	15050	9605	31	7

Table 2. Mission Sustainment Requirements

D. TRANSPORTERS

This analysis employs both air and surface transporters. In accordance with OMFTS, the air transporters are the MV-22 Osprey and the CH-53E Sea Stallion. The surface transporters are the LCAC and the AAAV.

1. Assumptions

a. Transporters are deployed in thé ARG/MEU(SOC) in the following numbers:

LCAC	AAAV	MV-22	CH-53E
7	13	12	4

b. Both air and surface transporters are used in establishing the force ashore. For sustainment, only the MV-22 is used.

c. During establishment, personnel are transported via MV-22, LCAC and AAAV, with the majority moving via MV-22. All equipment, except M198 Howitzers, is moved via LCAC. M198s are moved via CH-53E.

d. During sustainment, all cargo is transported externally.

2. Transporter Availability

Estimating the number of sorties available per day for each type of air and surface craft represents the final modeling input. With availability determined, comparisons between requirements and available resources can be made. Availability determination is conducted separately for air and surface assets.

a. *Air*

Sorties available per day are a function of the number of each type of aircraft, a projected readiness, and a sustained sortie rate per day planning factor. This relationship is seen in the following equation:

$$S_j = \sum_j N_j * R_j * SSR_j$$

Where S_j = expected total of available sorties for aircraft type j per day
N_j = number of aircraft of type j deployed
R_j = expected readiness of aircraft type j, [Ref. 8].
SSR_j = expected sustained daily sortie rate for aircraft type j, [Ref. 1] and [Ref. 9].

Fractional results are rounded down.

The actual allocation of these sorties to particular tasks is completed by the MEU(SOC) staff as required. During the establishment period, readiness of all air transport types is

assumed to be 100%. This is a reasonable assumption given that there is adequate time to prepare for the mission. Sustainment, unlike establishment, implies operations of extended duration. For this reason, sustained readiness will be less than 100% as all aircraft will undergo maintenance periods, either routine or emergent, that will remove them from flying status for the duration of the maintenance period.

Table 3 reflects the figures used and the values derived for all aircraft types modeled.

Aircraft Type (j)	S_j	N_j	R_j	SSR_j
MV-22 (Establishment)	48	12	1.0	4, (internal cargo)
MV-22 (Sustainment)	30	12	.85	3, (external cargo)
CH-53E (Establishment)	10	4	1.0	2.5, (external cargo)
CH-53E (Sustainment)	6	4	.60	2.5, (external cargo)

Table 3. Air Sortie Generation Summary

b. *Surface*

In this analysis, LCAC are employed only in the establishment phase. For this reason, LCAC availability is not determined as sorties per LCAC. Instead, only the expected number of LCAC available to transport equipment is computed. This value is computed from:

$$L = n^*r$$

Where L = number of available LCAC
n = number of LCAC deployed with the ARG
r = expected LCAC readiness, [Ref. 8]

Fractional results are rounded down.

In this analysis, it is assumed that $n = 7$ and $r = .80$, so the number of available LCAC is 5 per day. Although not accounted for in this analysis, use of the LCAC for an extended duration, such as in a sustainment phase, will require consideration of a operational crew day constraint. For the missions modeled in this analysis, it reasonable to assume that the constraint on LCAC availability would consist solely of a readiness factor.

E. MODELS

Models were constructed for both establishment of the force ashore and for its subsequent sustainment. The goal of modeling the establishment phase is to capture the time required for each force package to move from ship-to-objective. This exercise serves to demonstrate the fact that transporters used in sustainment must also operate to establish the force. Modeling the sustainment phase is aimed toward capturing the number of sorties required to meet the force's daily sustainment requirements. Since transporter assets must also support the tactical mobility requirements of the force ashore, comparing the number of sorties required to satisfy daily sustainment requirements with the number of sorties available provides insight into the level of competition for transporter assets.

1. Establishment

Establishing the force ashore consists of transporting personnel, equipment, and two days of supply (DOS) from ship-to-objective. Deploying with two DOS for MREs and ammunition is generally attainable; however, water and fuel amounts are constrained by the number of mobile-loaded containers and towed water trailers deployed with the force. As a result, larger forces may be unable to move ashore with

two DOS of water or fuel. The net effect on sustainment is that these commodities will require resupply soon after establishment.

Personnel are moved primarily via MV-22; the only exceptions are vehicle operators who move ashore with their equipment via LCAC and those people assigned to AAAVs. Some supplies are man-packed, but most are loaded in equipment. With the exception of AAAVs and M198 howitzers, all equipment is moved from ship-to-shore via LCAC. Once ashore, equipment delivered by LCAC self-deploys to the objective. AAAVs self-deploy from ship-to-objective. When required, M198 howitzers are transported by CH-53Es from ship-to-objective.

The aforementioned components are modeled as sorties required to establish the force ashore. A sortie is defined as a round-trip movement: ship-to-shore-to-ship for LCACs and ship-to-objective-to-ship for air assets. AAAV sorties are ship-to-objective only.

a. ***Air***

A MV-22 can carry 24 combat-loaded Marines, [Ref. 8]. Therefore, the number of MV-22 sorties required for people movement is given by:

$$S_{MV-22} = N/24$$

Where N = number of people to be transported via MV-22

Fractional results are rounded up.

A CH-53E can carry one M198 Howitzer, [Ref. 8]. Therefore, the number of CH-53E sorties required is given simply by the number of howitzers requiring transport.

b. *Surface*

Rather than determine LCAC sorties solely based on the LCAC's weight capacity, this model also considers cargo square footage so as to prevent exceeding area or weight limitations. Even so, the method used in this model does not seek to fill every square foot available. Instead, it represents capacity by vehicle type, i.e., the LCAC's capacity for a load consisting exclusively of one vehicle type. In other words, all loads are homogenous by vehicle type. While this does not reflect how an actual offload would occur, it does provide a legitimate approximation for determining the number of sorties required. To this end, vehicles were grouped into four categories: HMMWVs, 5-ton trucks, Logistics Vehicle Systems (LVS), and Light Armored Vehicles (LAV). All HMMWVs and trailer-mounted equipment are grouped in the HMMWV category; the remaining categories consist solely of their namesake. Given this method, the number of LCAC Sorties required to establish the force can be computed from:

$$S_{LCAC} = \sum_j V_j / C_j$$

Where V_j = number of vehicle type j requiring movement ashore
C_j = the number of type j vehicles that comprise one homogenous LCAC load, [Ref. 10].

Fractional results rounded up.

In this analysis, AAAVs do not conduct round-trip sorties. As a result, for the missions in which they are modeled, AAAVs contribute people movement at their capacity for one trip only. AAAVs are capable of moving a crew of 3 and 18 passengers

for a total of 21 combat-loaded Marines. In the HA/DR mission, the AAAV is modeled as a supply transporter; therefore, only 5 people are associated with each AAAV for establishment purposes.

Table 4 summarizes the sorties by mission and transporter type required for establishing the force ashore.

Mission	MV-22	CH-53E	LCAC
HA/DR	6	0	19
NEO(S-P)	9	0	12
NEO(N-P)	20	0	14
Security Op	13	6	18
Enabling Force Op	38	6	26

Table 4. Establishment Sortie Requirements

2. Time Required To Establish The Force Ashore

The time required for establishing the force ashore is a function of the number of sorties required for movement, the maximum available sorties per day for each transporter type, the distances involved, and the transporter's performance characteristics.

a. *Air*

The time required to move the air-transported component of a force package ashore, T_{Air}, is a function of the time per sortie, the number of sorties required, and the number of available aircraft. Time per sortie, T_S, is calculated using four components: loading time, ingress flight time, unloading time, and egress flight time. Values for loading and unloading times were taken from [Ref. 8]. Flight times are calculated by dividing the ship-to-objective distance in miles by speed in knots. Egress

flight time is modeled differently from ingress flight time due to a need to exit via a different route or evade enemy air defenses. T_{Air} is given by:

$$T_{Air} = (T_S * N_S) / N_A$$

Where T_{Air} = total air movement time in hours
T_S = time per sortie in hours
N_S = number of sorties required
N_A = number of available aircraft

The model does not include any allowance for weather related restrictions which could preclude the MEU(SOC) from flying any sorties on a given day.

b. ***Surface***

The surface component of establishing a force ashore is modeled in waves. A wave equates to a group of LCAC sorties conducted concurrently. Each wave can have the following time components: loading time, LCAC ingress time, unloading time, LCAC egress time, and ground equipment transit time to the objective. The first and last waves will have different total times than the intervening waves. If T_1 is the time required for the first wave, T_2 is the time required for each middle wave, and T_3 is the time required for the last wave, then total surface movement time, $T_{surface}$, is given by

$$T_{surface} = T_1 + (T_2 * C) + T_3$$

where C = (total number of waves – 2).

The first wave of LCACs is pre-loaded with equipment. Therefore, T_1 does not involve a load time component, nor does it include a ground equipment transit time component. T_2 does not include a ground equipment transit time component. T_3 includes the ground equipment transit time component but omits the LCAC egress time

component. Therefore, surface movement time ends with the final shore-to-objective ground equipment transit. The total number of waves required is calculated by dividing the required number of LCAC loads by the number of available LCACs and rounding up. LCAC Ingress and LCAC Egress times are equal; they are calculated by dividing the ship-to-shore distance in miles by the expected LCAC speed in knots. LCAC speeds, load times and unload times are from [Ref. 11]. Ground equipment transit time is calculated by dividing shore-to-objective distance in miles by average ground speed in miles per hour. An average ground speed of 25 miles per hour was used in all cases.

While AAAVs are part of the model's surface movement, the time they require to move from ship-to-objective is a subset of the time required for moving equipment ashore via LCAC and may therefore be ignored. The model does not account for potential weather or sea-state delays. It also does not account for time required for mine-clearing operations, additional time needed for LCAC queuing at the ship, or for obstacles ashore slowing movement to the objective.

3. Sustainment

Sustainment transportation demands depend on the amount of supplies required ashore. In this model, all sustainment is moved via MV-22 external lifts. Whereas surface movement is capable of delivering greater amounts from the ship to the shore than air movement, air movement is more consistent with OMFTS ideals because it obviates the need for maintaining a secure beach landing area and secure lines of communication from the beach to the objective area. It should be reiterated that OMFTS does not preclude the use of the beach for throughput of either forces or sustainment,

[Ref. 5]. Among air assets, the MV-22 is preferred to the CH-53E due to its greater speed, larger numbers in the ACE, and higher projected availability. CH-53Es can be thought of as on-call for any heavy-lift mission requirements such as the movement of artillery.

Sustainment sorties are allocated to either dry or wet requirements. Therefore, dry and wet requirements are treated separately.

a. ***Dry***

MREs and ammunition are treated as continuous variables and the number of sorties required to transport dry sustainment requirements, S_{dry}, is:

$$S_{dry} = \sum_j D_j / C_{dry}$$

Where D_j = amount of commodity j required in pounds
C_{dry} = MV-22 external lift capacity in pounds, (10,000), [Ref. 8].

Fractional results rounded up.

b. *Wet*

Fuel and water are treated as discrete variables because their movement is limited not solely by weight, but also by the capacity of the containers in which they are transported. This relationship is seen in the following equations:

$$NC = \sum_{j} W_j / CC$$

$$S_{wet} = NC / LC$$

Where NC = number of wet containers required ashore per day
W_j = amount of wet commodity j required daily in gallons
CC = container capacity in gallons, (500 gallons)
LC = MV-22 sortie external container lift capacity, (2), [Ref. 8]
S_{wet} = number of sorties required to transport wet requirements.

Fractional results rounded up.

IV. RESULTS

This chapter provides model results as well as a discussion of the insight yielded by these results. Results are presented separately for establishment and sustainment categories.

A. ESTABLISHMENT

Table 5 reflects the results of modeling the time required to establish each mission's force package ashore.

Mission	Surface (Hrs)	Air (Hrs)
HA/DR	5.0	0.8
NEO(S-P)	11.3	1.3
NEO(N-P)	11.3	2.5
Security Op	14.5	2.5
Enabling Force Op	21.0	5.0

Table 5. Time to Establish the Force Ashore

As expected, as force packages increase in size, the time required to establish the force ashore increases. The model's requirement to move all equipment except artillery via surface ensures that the surface movement time is significantly longer than the air movement time. Additionally, this disparity between surface movement time and air movement time demonstrates the ongoing requirement for synchronization between surface and air movements in an OMFTS environment.

B. SUSTAINMENT

Table 6 reflects the numbers of sustainment sorties required for either assault rate or sustained rate LPFs. The difference between assault and sustained rate LPFs is reflected only in Class V(W) (ammunition) requirements; Class I (food and water) and Class III (Fuel) requirements do not vary with rate. Also reflected is the number of sorties available for tasks other than sustainment for each mission. These tasks include tactical mobility, deception, medevac, and emergency maintenance support.

	Assault Rate		Sustained Rate	
Mission	**Required Assault Rate Sorties**	**Remaining Available MV-22 Sorties**	**Required Sustained Rate Sorties**	**Remaining Available MV-22 Sorties**
HA/DR	10	20	10	20
NEO(S-P)	9	21	8	22
NEO(N-P)	13	17	12	18
Security Op	21	9	17	13
Enabling Force Op	32	-2	27	3

Table 6. Sustainment Sortie Requirements

With the exception of the Enabling Force Operation's assault rate requirements, sufficient MV-22 sorties are generated to meet each force's daily sustainment requirements. Recall that Table 3 indicated a total of 30 available MV-22 sorties each day. The remaining available sortie columns provide an important and perhaps more telling result. Remaining available sorties are simply the difference between total availability and sustainment requirements. This figure represents the number of daily sorties a commander can expect to have remaining if he fully meets the force's sustainment requirements. It is reasonable to assume that as missions increase in intensity, the number of sorties required for tasks such as tactical mobility, medevac,

deception, and emergency maintenance support will approach or exceed the number of sorties required for sustainment. For example, 8 MV-22 Sorties, or more than 25% of daily available sorties, are required to relocate one Rifle Company with Weapons Company attachments. For this reason, it becomes very likely for the more demanding missions that sorties available will not satisfy total sortie requirements. This implies a limitation on the feasibility of sea-based sustainment in support of OMFTS.

The nature of this analysis does not allow for a strict feasibility determination. Instead, it is helpful to think of levels of feasibility in terms of the percentage of total sorties required for a particular mission's sustainment. One manner of assessing the feasibility of sea-based sustainment via MV-22 for the missions analyzed is found in the traffic light paradigm. Specifically, 'Green' represents sustainment sortie requirements up to 50% of the total available sorties, 'Yellow' represents from 50% to 100%, and 'Red' is beyond 100%. In other words, an assessment of 'Green' indicates that a commander should be able to meet all tasks with available sorties. 'Yellow' indicates that a commander can anticipate difficulty in meeting all tasks with available sorties. 'Red' indicates that sustainment alone consumes all available sorties. Table 7 reflects a feasibility assessment using these definitions.

Mission	Assault Rate	Sustained Rate
HA/DR	Green	Green
NEO(S-P)	Green	Green
NEO(N-P)	Green	Green
Security Op	Yellow	Yellow
Enabling Force Op	Red	Yellow

Table 7. Sustainment Feasibility Assessment

Determining which commodities demand the most sorties can help identify areas where improvements may be of the greatest benefit. Figure 2 reflects the division of total sustainment sortie requirements between wet and dry commodities.

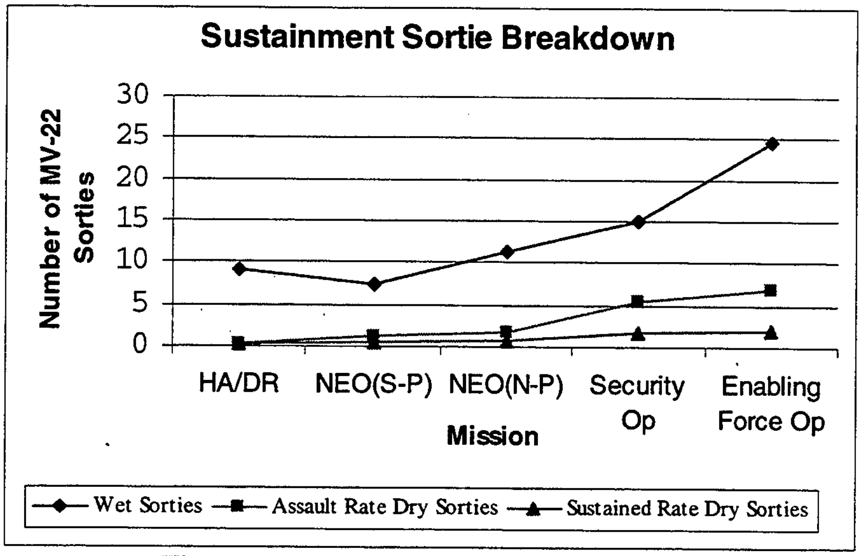

Figure 2. Sustainment Sortie Breakdown

Figure 2 helps demonstrate the extent to which the wet (water and fuel) requirements drive sustainment sortie numbers for the missions analyzed. It is particularly telling that the wet requirements for the most permissive mission, the HA/DR, exceed the dry requirements for the most operationally intense mission, the Enabling Force Operation. The fact that the HA/DR employs 2/3 the personnel and 1/2 the number of equipment items used in the Enabling Force Operation serves to reinforce this point.

V. EXCURSIONS

The results detailed in Chapter IV were derived from the expected values for sustainment requirements and transportation capacity. It is, therefore, especially important to examine how the models used react to changes in the input values. This examination is a type of sensitivity analysis that takes the form of three excursions. First, sustainment requirements were varied upward from the base case that used the LPFs from the MAGTF Data Library, [Ref. 1]. Second, the effect of decreases in sortie availability over time was examined. Finally, the impact of augmenting the MV-22 with CH-53E sorties not required for heavy lift tasks was examined.

A. SUSTAINMENT REQUIREMENTS

As discussed in Chapter IV, sufficient sorties are generated for sustainment requirements for all but the most demanding mission. Therefore, it can be surmised that a sustainment problem is unlikely when actual usage is less than that projected using the LPFs from [Ref. 1]. But what if actual consumption exceeds the requirements projected using the LPFs? This question was addressed by adding a percentage factor to the original requirement and then comparing the sorties required for transporting the increased amounts against the available sorties. MRE usage was not varied, however; the same number of people will not consume more MREs than the original requirement. All other commodity requirements (water, fuel, and ammunition) were subject to variation.

Table 8 reflects the results of this excursion using the traffic light paradigm. If feasibility changes due to an LPF increase, that particular cell is highlighted. For example, at LPF+10%, the Enabling Force Operation's sustained rate sortie requirements changes from the 'Yellow' reflected in Table 7 to 'Red'.

	Assault Rate			Sustained Rate		
Mission	LPF+10%	LPF+25%	LPF+50%	LPF+10%	LPF+25%	LPF+50%
HA/DR	Green	Green	Yellow	Green	Green	Yellow
NEO(S-P)	Green	Green	Green	Green	Green	Green
NEO(N-P)	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Security Op	Yellow	Yellow	Red	Yellow	Yellow	Yellow
Enabling Force Op	Red	Red	Red	Red	Red	Red

Table 8. Sustainment Feasibility Assessment Excursion Results

As expected, increased requirements demand increased sorties. The key insight yielded by this excursion is the fact that actual usage above LPF projections serves to push the point where sustainment requires all available sorties down the spectrum of operational intensity. In other words, sustaining smaller forces involved in less intense operations becomes more difficult. This observation is especially applicable to an OMFTS environment where the high tempo of operations is not likely to wane. It also is a quantitative indication of why it is so desirable to effect a decrease in the amount of sustainment required.

B. SUSTAINMENT SORTIE AVAILABILITY

The expected number of MV-22 sorties available that was used in the modeling process assumed aircraft readiness was constant. It is reasonable to assume that aircraft readiness will decrease during extended operations. This decrease in readiness over time can result from many factors, e.g. combat attrition, accidents, corrective maintenance requirements, or preventive maintenance required at specific operational hour limits.

How does this reduction in readiness over time affect the ability to sustain missions ashore? This question was addressed through the following equation:

$$S_t = N * R_t * SSR$$

Where S_t = the number of sorties available on day t
N = the number of MV-22's deployed, (12)
R_t = MV-22 readiness on day t
SSR = MV-22 sustained external cargo sortie rate, (3), [Ref. 9].

Readiness equates to a Mission Capable rate. It was modeled as follows: the range for t is 1 to 7 days with R_1 = .85 and R_7 = .70. Figure 3 compares the impact of decreased readiness over this period on available MV-22 sorties with the sustainment requirements from the Enabling Force Operation.

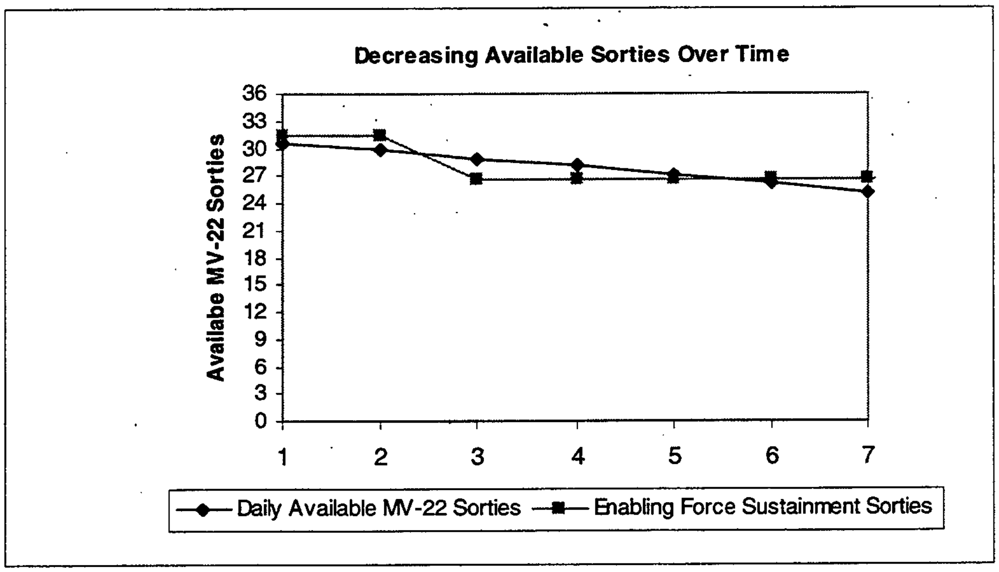

Figure 3. Decreased Available Sorties Excursion

The graph depicts how assault rate and sustained rate requirements might be apportioned in an actual operation. In this case, two days of assault rate sustainment are followed by five days of sustained rate sustainment. The net effect of decreased readiness is decreased available sorties. As a result, sustainment sortie requirements consume an increasing

percentage of available sorties. For instance, the graph reflects feasibility for the Enabling Force Operations' sustained rate requirement shifting from 'Yellow' to 'Red' on day 5.

C. CH-53E ASSISTANCE IN SUSTAINMENT

As detailed in Chapter IV, wet requirements generate the greatest transportation demands. What if available CH-53E sorties were employed to mitigate this situation? The MEU(SOC)'s four CH-53E aircraft generate six sorties per day, (Table 3). Four CH-53E sorties using the 2400 gallon fuel capacity of the internally loaded Tactical Bulk Fuel Distribution System can meet all daily fuel requirements for the missions examined in this analysis. A MV-22 is limited to two 500-gallon bladders carried externally. Therefore, it can be seen that, even when fractional sorties are discounted, one CH-53E fuel sortie allows two MV-22 sorties to be reassigned to non-sustainment tasks.

It should be noted that no system such as the Tactical Bulk Fuel Distribution System exists for the transportation of bulk water. Therefore, the CH-53E's assistance in water distribution is not as significant. Specifically, a CH-53 can lift three 500-gallon bladders where the MV-22 is again limited to two 500-gallon bladders.

VI. ROLE FOR THE LCU IN OMFTS

The LCAC is envisioned as the only surface landing craft in an OMFTS environment. Currently, an ARG / MEU(SOC) deploys with a mix of two types of landing craft: the LCAC and the LCU. Comparatively, LCACs are capable of significantly faster speeds. Also, their air-cushion characteristic allows them access to many areas where conventional landing craft like the LCU are not usable. LCUs, however, offer a significantly larger weight capacity and enough available area to carry larger amounts of certain equipment types. Should LCUs be ignored in OMFTS or are there circumstances in which their employment is advantageous?

This question was addressed by creating a linear program to determine at what ship-to-shore distance, if any, a MEU(SOC) might consider including LCUs along with LCACs in the establishment of combat power ashore.

A. MODEL

Indices

i landing craft type (LCAC, LCU)

j vehicle type (HMMWV, 5-ton, LVS, LAV)

Data

$TIME_i$ = round trip sortie time for landing craft type i (minutes)

$NUMREQ_j$ = number of vehicles of type j required ashore

MAX_i = max number of sorties required if landing craft type i is used exclusively

$CAPACITY_{ij}$ = number of vehicles of type j that can be loaded on a landing craft of type i

Decision Variables

Y_{ij} = number of landing craft type i sorties assigned to transport type j vehicles

Formulation

$$\min \sum_{j} \sum_{i} TIME_i * Y_{ij}$$

$$s.t.$$

$$\sum_{i} CAPACITY_{ij} * Y_{ij} \geq NUMREQ_j \ \forall_j$$

$$\sum_{j} Y_{ij} \leq MAX_i \ \forall_i$$

$$Y_{ij} \in \text{integer}$$

The objective function seeks to minimize the total time required to move the respective force package from ship-to-shore. The first constraint ensures that the required amounts of type *j* vehicles are assigned to a sortie. As was done previously in modeling LCAC sortie requirements for establishing the force ashore, vehicles were assigned to four categories: HMMWVs, 5-ton trucks, LAVs, and Logistics Vehicle Systems (LVS). Again, HMMWV figures include both HMMWVs and trailers; the remaining vehicle categories are comprised solely of their namesake. The second constraint ensures that the total number of landing craft type *i* sorties used does not exceed a set maximum. A final requirement is that the number of sorties assigned be integral.

The $TIME_i$, $NUMREQ_j$, and MAX_i data were taken from the Enabling Force Operation. MAX_i is number of sorties that would be required if landing craft type *i* was used exclusively. $CAPACITY_{ij}$ is from [Ref. 10]. The linear program was solved using the *What's Best* solver in an *Excel* Spreadsheet.

B. RUNS

The model was run using two separate operational scenarios. The first scenario involved sortie times that reflected launching LCACs and LCUs at the same distance from shore. The second scenario was adapted from the Marine Corps' STOM Concept Paper, [Ref. 6]. It describes AAAVs launching at 25 nautical miles from shore while LCAC launch from greater distances. This motivates the question of including LCUs if they are launched at a different distance than LCACs. Using LCAC sortie times from 50 nautical miles and LCU sortie times from various distances tested this scenario.

C. RESULTS

Table 10 indicates the results of the various model runs.

Scenario	Ship-to-Shore Distance	LCAC in Optimal Solution	LCU in Optimal Solution
1	≤ 10 nm	X	X
	> 10 nm	X	
2	LCAC = 50 nm LCU ≤ 25 nm	X	X
	LCAC = 50 nm LCU > 25 nm	X	

Table 10. Summary of Landing Craft Mix Linear Program Results

OMFTS envisions ship-to-shore standoff distances large enough to protect the ARG from shore-based missile threats. In situations where this threat is realized, the required standoff will certainly be greater than 10 nautical miles. In that case, the LCU will not be a viable option due to its slow speed. However, if the environment is more permissive, the LCU may complement the LCAC. The results of the second scenario runs indicate a potential role for the LCU in OMFTS. A more specific interpretation of

the second scenario's results is that the LCU's slow speed alone is not enough to prevent it from contributing positively to an operation with OMFTS-type ship-to-shore distances.

VII. CONCLUSIONS

OMFTS and STOM seek to minimize the support footprint ashore through sea basing. They do not, however, preclude establishing support ashore when necessary. Neither do they mandate air-only sustainment of forces ashore when delivery of supplies via surface means is practicable. These facts reflect the pragmatic nature of the planners crafting the development of these concepts. Surface delivered sustainment is decidedly slower than air-delivery; it also requires secure or at least defended lines of communication ashore. If these restrictions are not binding, however, surface delivered sustainment offers the ability to transport greater amounts of material at one time. This notwithstanding, it is reasonable to assert that Marine Corps' planners envision an environment with no established support areas ashore and air-only sustainment of forces ashore as the operational template for which OMFTS and STOM are best suited. This analysis provides some measure of how quickly air-only, sea-based sustainment of forces ashore becomes a difficult proposition.

Although, this analysis does not allow a strict feasibility assessment of sea-based sustainment, it is possible to identify several implications and potential areas of interest as the development of OMFTS, STOM, and SBL continues. This analysis demonstrates the inherent difficulty of sea-based sustainment over the distances associated with OMFTS. Air-delivered sustainment implies a high degree of competition for finite available sorties. This competition occurs because sustainment requires a significant percentage of available sorties that have traditionally been reserved primarily for tactical mobility requirements. This analysis revealed several situations where sustainment alone required more than the total amount of available sorties. Water and fuel requirements

drive the demand for sustainment sorties. This occurs in part because of the manner in which they must be transported. Therefore, improvements in how water and fuel are transported can have a direct impact on reducing the number of sorties required to transport them. Additionally, this analysis addresses a potential mix of surface landing craft in an OMFTS environment. The combined results of these examinations suggest that planners should continue to address the exact nature of sea-based sustainment of forces ashore. They also provide starting points for further, more detailed analysis that can assist in the ongoing concept development. Areas of interest for extension or further study are numerous. They include the impact of surface-delivered sustainment, the time required per day to transport sustainment requirements, the impact of selective offload requirements on ARG embarkation capacities, as well as the modeling in greater detail of sorties required for tactical mobility, medevac, deception, and emergency maintenance support.

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